UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/720,035	11/21/2003	Francis Yu-Hei Tsang	35811-00001	2542

22334 7590 11/22/2005

PETER F WEINBERG
GIBSON DUNN AND CRUTCHER LLP
SUITE 4100
1801 CALIFORNIA STREET
DENVER, CO 80202

EXAMINER	
GREENE, DANIEL LAWSON	
ART UNIT	**PAPER NUMBER**
3663	

DATE MAILED: 11/22/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/720,035	TSANG ET AL.	
	Examiner	Art Unit	
	Daniel L. Greene Jr.	3663	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *10 August 2005*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-78* is/are pending in the application.

4a) Of the above claim(s) *1-21,26 and 30-78* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *23-25 and 27-29* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *21 November 2003* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *2/6/04, 8/12/05.* 8/30/05
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Election/Restrictions

1. Applicant's election without traverse of Group 1, Claims 1-29, species:

3a. The embodiment wherein the semiconductor is a p-type semiconductor,

4b. The embodiment wherein the nuclear material is in solution with the semiconductor material,

5a. The embodiment wherein the metallic contact layer forms a low resistance contact,

6. The embodiment wherein the liquid semiconductor material is an alloy of chalcogen with metal consisting of selenium with sodium,

7b. The embodiment wherein the nuclear material is non-fissile,

9. The embodiment wherein the type of radioactive isotope consists of a beta particle emitter only,

in the reply filed on 8/12/2005 is acknowledged.

2. Claims 1-22, 26 and 30-78 are withdrawn from further consideration pursuant to 37 CFR 1.142(b) as being drawn to a nonelected Inventions and species, there being no allowable generic or linking claim. Election was made **without** traverse in the reply filed on 8/12/2005.

Drawings

3. The replacement drawings of Figures 4 and 11 received on 8/12/2005 are acceptable, however the drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, the plurality of nonconductive spacers placed between the first metallic contact layer and second metallic contact layer as disclosed in claim 27 must be shown or the feature(s) canceled from the claim(s). No new matter should be entered.

Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter, which the applicant regards as his invention.

Specification

4. The specification is objected to under 35 U.S.C. 112, first paragraph, as failing to provide an adequate written description of the invention and as failing to adequately teach how to make and/or use the invention, i.e. failing to provide an enabling disclosure.

a. There is no adequate description nor enabling disclosure of how and in what manner the liquid semiconductor is purified or scrubbed of unwanted fission fragments as disclosed in, for example, pp 9 lines 27-30, pp 10 lines 17-18, pp18 lines 26+ and pp 19 lines 1-7. There is also no adequate disclosure of how and in what manner a heat extractor can perform both heat extraction and semiconductor purification. The specification only discloses the desired results without providing any description of how such is accomplished hence the disclosure is insufficient and nonenabling.

b. There is no adequate description nor enabling disclosure of how and in what manner fissile material may be added intermittently to replace the fissile

material burned up in the fission process as disclosed in, for example, pp 9 lines 30+, pp 10 line 18, and pp 19 lines 4-7. There is also no adequate disclosure of how and in what manner a heat extractor can perform both heat extraction and fissile material replacement. The specification only discloses the desired results without providing any description of how such is accomplished hence the disclosure is insufficient and nonenabling.

c. There is no adequate description nor enabling disclosure of how and in what manner the cooling loop is maintained in liquid form. It is not seen wherein the specification takes into account the thermal losses inherent in transporting the hot semiconductor liquid from the reaction cite to the coolers and back, hence the disclosure is insufficient and nonenabling.

d. There is no adequate description nor enabling disclosure of how and in what manner the nuclear voltaic cell is heated so as to melt the liquid semiconductor as disclosed in, for example, pp14 lines 1-11. There is no disclosure of how an external heating source is to be incorporated with the cell in order to melt said semiconductor or how such is accomplished, hence the disclosure is insufficient and nonenabling.

e. There is no adequate description nor enabling disclosure of how and in what manner "persons familiar with the art" are to select the materials of construction of the entire invention in order to operate as disclosed. Applicant again has stated the desired results of the materials to be selected, for example, pp13, lines 12-17, "As persons familiar with the art will understand, the Ohmic

Contact 10 is preferably made from a metal such that no, or a minimal barrier, exists between the Ohmic Contact 10 and the Liquid Semiconductor 20. Furthermore, as persons familiar with the art will understand, the Schottky Contact 30 is preferably made from a metal such that when placed in contact with the Liquid Semiconductor 20 a substantial electrostatic barrier is created across the Liquid", however it is not seen wherein specific examples of materials that accomplish the desired effect are disclosed. It is not seen wherein specific materials that are compatible with each other so as to present an operative embodiment are disclosed, hence the disclosure is insufficient and nonenabling.

g. There is no adequate description nor enabling disclosure of the overall dimensions of the invention. Page 13 lines 22-25 disclose that the cross section of the strata making up the active parts of the invention are .0163 cm however it is not seen where other dimensions are disclosed to present an operative embodiment. There is also no adequate description of how and in what manner the device can be scaled up to the systems disclosed in, for example figures 9-11 including exactly how and in what manner the liquid semiconductor can be forced to flow through the nuclear voltaic cells in a useful manner.

Claim Rejections - 35 USC § 112

5. Claims 23-25 and 27-29 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement. The claim(s) contains subject

matter, which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention for the reasons set forth in section 4 above.

Additionally the specification appears to only disclose METAL contacts, not METTALIC contacts. See the discussion of this topic in section 4e above.

6. Claims 23-25 and 27-29 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

a. There is no proper antecedent basis for all terms present. See for example "an electrical load" in claim 24, "said first substrate", "second substrate", "axially opposed" and "a mandrel" in claim 29, etc.

b. Claim 23, 27, and 28 are vague, indefinite and incomplete in what all is meant by and encompassed by the phrase "metallic contact layer". Accordingly the metes and bounds of the claim are undefined. See the discussion of this topic in section 4e above.

c. Claim 23 is vague, indefinite and incomplete. The claim does not positively recite that the liquid semiconductor actually contacts the metallic contact layers, hence the metes and bounds of the claim are undefined.

d. Claim 27 is vague, indefinite and incomplete in what all is meant by and encompassed by the phrase "with said liquid semiconductor interspersed there

between" because this phrase can be interpreted to mean the liquid semiconductor is between the spacers only, to the exclusion of the metallic contacts. The current claim language does not require the liquid semiconductor to be in contact with either contact layer, hence the metes and bounds of the claim are undefined.

e. Claim 28 is vague, indefinite and incomplete in what all is meant by and encompassed by the phrase "said liquid semiconductor flows between said first metallic contact layer and said second metallic contact layer" because the limitation "flows" does not connote any particular "flow" per se. The limitation "flows between" is considered to incorporate flow back and forth from one contact to another as well as straight through the channel that is bounded on either side by the contacts, hence the metes and bounds of the claim are undefined.

f. Claim 29 is vague, indefinite and incomplete in what all is meant by and encompassed by the limitation "axially opposed" since no axis has been set forth. Accordingly the metes and bounds of the claim are undefined.

g. Claim 23 is vague, indefinite and incomplete in what all is meant by and encompassed by the phrase "positioned facing said first metallic contact layer" because the claim does not disclose what is considered to be the "face" of the second metallic layer such that it can be considered to be "facing" the first metallic layer, hence the metes and bounds of the claim are undefined.

h. Claim 27 is vague, indefinite and incomplete in what all is meant by and encompassed by the phrase "a plurality of nonconductive spacers are placed

between said first metallic contact layer and said second metallic contact layer". The claim fails to disclose where or how said spacers "are placed" including exactly what they are "spacing". Additionally the term "spacer" does not connote any particular structure, per se, and therefore does not require said "spacer" to actually maintain the structural "space" between said contact layers. The claim language does not expressly require that the spacers physically contact said contact layers, nor that they maintain a space between said contact layers, hence the metes and bounds of the claim are undefined.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of

35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

8. Claims 23-25, 27 and 28 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent 6,118,204 to Brown in view either Denninger or U.S. Patent 5,606,213 to Kherani et al. and further in view of any of U.S. Patent 5,260,621 to Little et al., Godlezsky et al., Yu et al., Kulkarni et al., Price et al., Matthiesen et al., or Enderby et al.

Brown discloses a nuclear voltaic cell comprising: a first metallic contact layer (5), and a second metallic contact layer (6) positioned facing said first metallic contact layer, with a semiconductor ((2), (4), (3)) interposed in between, wherein said semiconductor contains a solution of a radioactive isotope and said first metallic contact layer forms a Schottky contact with said semiconductor, and said second metallic contact layer forms a low resistance or Ohmic contact with said semiconductor; and

an electrical circuit (7) connecting said first metallic layer to said second metallic layer in, for example, figures 1-4, column 4 lines 49+, column 5 lines 1-15, 42-52, column 6 lines 8+, column 7 lines 1-13 and 40+, column 8 lines 1-23 and 52-56 and column 10 lines 53-57 wherein it is understood that Ohmic contacts are clearly disclosed in column 5 lines 10-12.

Brown does not appear to specifically disclose the use of a Schottky contact or a liquid semiconductor, however Brown does disclose the potential

difference (i.e. the voltage) between the two electrodes is equal to the difference in their work functions, i.e. their Fermi potential difference (column 6 lines 62-65).

Denninger is a lesson plan for teaching Semiconductor Physics 1. Denninger teaches that it is old and well known in the semiconductor physics art that a Schottky contact is formed any time there is direct contact of a metal with a semiconductor, hence Brown inherently has Schottky contacts wherever metal directly contacts the semiconductor. (It is noted that Brown does not specifically discloses that BOTH electrodes are connected with Ohmic contacts.)

Kherani et al. column 6 lines 57+ is similar with Brown (column 6 lines 62-65) in that both Brown and Kherani et al. teach that the nuclear cell potential is essentially varied by the work function or Fermi level of the selected semiconductors and Kherani furthers this by teaching that the cell potential and power characteristics can be further extended by the use of metal semiconductor junctions, also known as Schottky barrier junctions (contacts).

If applicant is of the opinion that Brown does not inherently contain at least one metallic contact layer that forms a Schottky contact, then at the time of the invention it would have been obvious to one of ordinary skill in the art to have one of the metallic contact layers form a Schottky contact for at least the benefits of extending the nuclear cells potential (output voltage) and power characteristics as taught to be old and advantageous by Kherani et al.

Regarding the use of a liquid semiconductor, Brown column 10 lines 53-57 teaches that a higher density semiconductor results in more efficient energy capture from high-energy betas.

U.S. Patent 5,260,621 to Little et al., Godlezsky et al., Yu et al., Kulkarni et al., Price et al., Matthiesen et al., and Enderby et al. all set forth benefits of liquid semiconductors over solid semiconductors including:

Little et al. column 6 lines 19-51, Sufficiently high temperatures restores radiation damaged semiconductor material to its original state, i.e. higher temperatures and thus liquid state promotes annealing radiation damage.

Godlezsky et al. discusses the dynamics of liquid semiconductors and on pp 4962, first column, 3rd full paragraph, teaches that increased temperatures causes a denser six fold coordinated structure. (Note, the teachings of Brown with regard to density)

Yu et al. discusses the molecular dynamics of surface segregation in liquid semiconductors and in the introduction, second sentence teaches that impurities with lower surface tension than the host material will have a tendency to migrate towards the surface of said host material and vie versa, higher surface tension migrates away from the surface. This tendency is beneficial in the fact that it would allow for the selection of the semiconductor and the impurities (i.e. radioactive isotopes, fissile material, etc) contained within said semiconductor to be chosen such that said impurities would either migrate away from the surface of said semiconductor thus increasing the number of electron hole pairs

produced deeper within the semiconductor, or to migrate closer to the surface of said semiconductor such that the electron hole pairs are closer to the electrodes such that recombination is minimized.

Kulkarni et al. discusses the molecular dynamics of the structural and transport properties of liquid germanium (a semiconductor). Within the abstract it is taught the diffusion constant rises as temperature increases. A larger diffusion constant means impurities within the semiconductor will diffuse faster and become more uniform throughout said semiconductor. A large diffusion constant is beneficial to have because the fuel material will be more evenly distributed and thus provide an even distribution of generated power throughout the nuclear voltaic cell.

Price et al. page 3 first paragraph under Fig. 1 teaches that within 30 different semiconductors there is generally a significant increase in conductivity from the solid to liquid state. A significant increase in conductivity is a benefit because decreasing resistive losses within the semiconductor material causes an increase in efficiency of the device.

Matthiesen et al. is similar to Kulkarni et al. in teaching that the diffusion process in liquid semiconductors is important because of the desire for uniform diffusion of dopants (impurities).

Enderby et al. is a quite comprehensive report on liquid semiconductors reiterating many of the benefits already disclosed in the preceding references including that some semiconductors change from semi conductive to semi

metallic at certain temperatures. This is considered beneficial in that using a specific semiconductor with a specific transition temperature within the operating range of the nuclear voltaic cell would be considered self regulating by temperature, i.e. as the cell was operating and the temperature continued to increase, i.e. the decay of the fuel, at the point that the semiconductor transitions to semimetal the Fermi functions would change causing less electrons to reach the electrodes and a subsequent decrease in current which could be used to signal an over temperature condition necessitating increased cooling requirements or shutdown.

At the time of the invention, it would have been obvious to one of ordinary skill in the art to incorporate within Brown the use of a liquid semiconductor for the benefits of increased density (i.e. increased efficiency), increased diffusibility, increased conductivity, etc., as taught to be old and advantageous by any of the secondary references.

Claim 24 is clearly disclosed in Brown column 6 lines 46+, wherein electrical power is generated when an electrical load is applied to said electrical circuit.

Claim 25 is disclosed in Brown, wherein the type of the semiconductor is determined by at least the selection of the metal of the electrode contacting said semiconductor. Even applicants own specification page 13 lines 12-17 teaches that those familiar with the art are well aware that the selection of the materials of construction of the electrodes is dependant on the properties/effects desired.

Regarding claim 27, because of the indefiniteness of the claim language as explained in section 4 above, it is considered that the Krypton dispersed in the semiconductor material reads on the plurality of nonconductive spacers because Krypton is nonconductive and takes up space (i.e. a spacer) and is between the first and second metallic contact layers and the current claim language does not require anything further.

Regarding claim 28, Brown as modified above now includes liquid semiconductor material. It is inherent that any liquid will "flow" to fill its container. It is also considered to be inherent that there is at least some amount of flow, no matter how small, is occurring in any liquid at any time and therefore Brown reads on the claim language. See the discussion of this topic in section 4 above.

9. Claim 29 is rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent 6,118,204 to Brown in view either Denninger or U.S. Patent 5,606,213 to Kherani et al. and further in view of any of U.S. Patent 5,260,621 to Little et al., Godlezsky et al., Yu et al., Kulkarni et al., Price et al., Matthiesen et al., or Enderby et al. as applied to claims 23-25, 27 and 28 above, and further in view of U.S. Patent 3,344,289 to Knight.

Brown discloses applicant's invention as explained above, however Brown does not expressly disclose that the substrates (Due to a lack of antecedent issue with the term "substrate" the Examiner has considered said substrates to

be the metallic contact layers) are axially opposed to each other and wound around a mandrel.

The 1967 patent to Knight teaches it is notoriously old and well known in the nuclear voltaic cell art (nuclear batteries) to coil or roll up the materials of nuclear batteries for the benefits of doubling the efficiency of said batteries because of the geometry of the materials that accompanies rolling, i.e. the radioactive material is surrounded by more material capable of producing electron hole pairs, in column 2 lines 65+ and column 3 lines 1-8.

At the time of the invention it would have been obvious to one of ordinary skill in the art to wrap the invention of Brown around a mandrel for the benefits of decreasing the overall size of the battery for the same output and for doubling the efficiency as taught to be old and advantageous by Knight.

Conclusion

10. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

a. Thomas discloses the use of nonconductive spacers,

b. Shanks discloses wrapping and radioactive isotopes contained in liquid,

c. Cota et al. discloses radioactive isotopes contained in liquid.

11. Examiner's Note: Examiner has cited particular columns and line numbers in the references as applied to the claims for the convenience of the applicant. Although the specified citations are representative of the teachings in the art and are applied to the

specific limitations within the individual claim, other passages and figures may apply as well. It is respectfully requested from the applicant, in preparing the responses, to fully consider the references in entirety as potentially teaching all or part of the claimed invention, as well as the context of the passage as taught by the prior art or disclosed by the examiner.

12. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Daniel L. Greene Jr. whose telephone number is (571) 272-6876. The examiner can normally be reached on Mon-Fri 8:30am - 5pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jack Keith can be reached on (571) 272-6878. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

13. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

DIG
2005-11-15

JACK KEITH
SUPERVISORY PATENT EXAMINER